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A PARTIAL REVIEW OF MARINE SCIENCE IN WESTERN EUROPE. (U)

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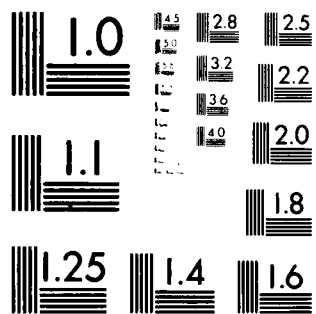


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A PARTIAL REVIEW OF MARINE SCIENCE IN  
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WAYNE V. BURT

1 OCTOBER 1980

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# A PARTIAL REVIEW OF MARINE SCIENCE

IN WESTERN EUROPE

WAYNE V. BURT

This review is based on visits to marine laboratories that were made between 1 January 1979 and 30 May 1980.

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## A PARTIAL REVIEW OF MARINE SCIENCE IN WESTERN EUROPE

### GREAT BRITAIN

#### I. Summary

There are at least 75 institutions of various kinds with programs of instruction and/or research in marine science in Great Britain. For this reason only a few of the larger, more important institutions are discussed in this report.

The British Institute of Oceanographic Sciences (IOS) dominates the scene. It is funded and managed by the government's Natural Environmental Research Council (NERC). IOS has a total of over 350 employees in five locations. The main laboratory in Wormley, just south of London, tends to concentrate on the deep oceans and has programs in physical, chemical, biological, geological, and geophysical oceanography. A branch at Bidston, formerly the Liverpool Tidal Institute, concentrates on waves, tides, and storm surges with some work on the dynamics of shallow seas. The branch at Taunton gathers statistical data on ocean waves around the United Kingdom for coastal engineering purposes and for planning related to usable energy from sea waves. The Taunton research staff also studies the dynamics of sediment movement in shallow shelf seas. A small contingent of IOS is located at the Laboratory of the United Kingdom Marine Biological Association in Plymouth. It carries out physical studies for the biologists and also studies the dynamics of shallow shelf seas around the UK including fronts, residual currents, and the distribution of bottom stresses.

A NERC division is located at Barry, Wales. It operates the whole fleet of governmentally owned oceanographic research ships which, with a few exceptions, including the two marine fisheries laboratories, provide ship time for the entire oceanographic effort in the UK. The Barry laboratory also purchases and maintains many major items of oceanographic equipment. In my opinion, this method of operation is not as efficient as the University National Oceanographic Laboratory System (UNOLS) in the US. The NERC ships tend to be overmanned. Ships the size of the RVs *Oceanus* and *Wecoma* (which in the US, would have crews of 10 or less) have crews of 25 or more in the UK.

There are large governmental marine fisheries laboratories at Lowestoft, on the coast of the North Sea, northeast of London, and in Aberdeen, Scotland. Both have important programs in descriptive physical oceanography in support of fisheries studies. Previously they concentrated on the North Sea and the waters surrounding the UK. However, the Lowestoft laboratory is now carrying out a major physical oceanographic study of the eastern basin of the North Atlantic because of its potential as an area for disposal of high level radioactive waste.

Three large laboratories that were formerly privately supported marine biology laboratories are now almost entirely governmentally supported (primarily by NERC) and operate very much like the government laboratories. The Dustaffnage Marine Research Laboratory at Oban is located in northwest Scotland. It has branched out into physical and chemical oceanography and is, to a large degree, marine-pollution oriented. The Plymouth laboratory

mentioned above, which has a small IOS contingent of physical oceanographers and some chemical oceanographers, is largely biological in nature. The Edinburgh Laboratory of the Scottish Marine Biological Association, which moved to Plymouth a decade ago to become the Institute for Marine Environmental Research, operates as a governmental laboratory. Its primary charter is to study marine pollution problems in estuaries and shallow coastal waters and the monitoring of plankton in the North Sea and North Atlantic.

Four universities, those at Liverpool, Southampton, and Bangor and Swansea (both in Wales) have departments of oceanography with strong research and teaching activities. The best known of these departments is the one at the University of Liverpool. It concentrates on physical and chemical oceanography. The department at the University of Southampton has programs in physical, chemical, geological, and biological oceanography and marine geophysics. The University College of North Wales at Bangor has a department of physical oceanography, with programs in physical and chemical oceanography and marine geotechnics, as well as a department of marine biology. I have not visited the department at the University College of Swansea, Wales. Until recently it had been the Department of Geology and Oceanography and its marine science activities were largely devoted to marine geology. Now it has branched out into physical, chemical, and biological oceanography.

The other university programs in the UK are operated by from one to half a dozen staff members who usually tend to specialize in one particular branch of oceanography. Two of these programs should be mentioned. The first is a large, important program in offshore engineering and technology at Heriot-Watt University in Edinburgh which is conducted largely in support of the offshore oil industry. The second involves the relatively large group working in the modeling of ocean and atmospheric dynamics in the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge.

## II. Comments

Few places in Great Britain are more than an hour's drive from the sea-coast. For this reason practically every university and college in the UK has some sort of program of research in one or more branches of marine science. In addition there are a number of major marine-oriented government laboratories and some smaller ones. One gets the impression that more money is spent for marine science in relation to GNP in the UK than in any other country. I have visited seven laboratories so far and plan to visit about a dozen more. In general the quality of the researchers and the research underway is very good. A higher percentage of the research in the UK is strictly applied research than is the case in the US. I have talked with several laboratory directors about future prospects. They are pessimistic about starting new programs and in general are not permitted to increase the size of their staffs. On the plus side, they seem to be confident that their budgets will be stable in real pounds in the near future. England is far more ocean-oriented than is the US. It is hard to imagine that applied ocean-oriented research will be diminished in the near future.

Institution: University of Liverpool.

Division: Department of Oceanography.

Key Personnel: Chairman, Prof. K.F. Bowen.

Trends: The department was almost entirely devoted to chemical ocean-

ography, in particular, the development and improvement of analytical techniques for the determination of various elements in sea water. Recently it has developed major programs in physical oceanography and has widened its base in chemical oceanography. It appears to be growing steadily.

Research Programs: Bowen does research on circulation, diffusion, and mixing in estuaries; the heat budgets of ocean upwelling; and the dependence of turbulence on height above the bottom in the Irish Sea.

Drs. R.M. Howe and R.I. Taite have been working for a number of years on the characteristics and movements of the Mediterranean water mass or "type" that flows out over the sill of the straits of Gibraltar and spreads at depth over much of the North Atlantic Ocean. Dr. Peter Hughes has studied the process of upwelling for the past decade. He is particularly interested in the rich upwelling area off northwestern Africa. Dr. J.P. Riley has spent much of his time on trace element chemistry of sea water. Now he is also working on the organic chemistry of fresh water. Dr. M.R. Preston is working on the organic chemistry of estuaries and the chemical changes that take place when fresh and salt water mix.

Funding: Sixty percent of the department's funding comes from the university and forty percent from government agencies. The Natural Environmental Research Council is the principal source of funds, while the Department of Energy contributes lesser amounts for pollution-related research.

Comments: This department is well-known for the excellence of its research programs. Students come from all over the world to learn chemical oceanography. A special course for third world students is well attended. It is a practical course in marine pollution. Bowen is also known for his research in physical oceanography. See ESN 33-10:425 (1979) and ONRL Report R-1-79.

Institution: Institute of Oceanographic Sciences (IOS).

Division: The Bidston Branch near Liverpool, which was the Liverpool Tidal Institute until 1973.

Key Personnel: Director, Dr. David Cartwright.

Trends: The laboratory has grown very rapidly since it became a branch of the Institute of Oceanographic Sciences. Much of its research is applied and practical, and its results can be used to solve problems associated with the oceans and seas surrounding the British Isles. For this reason the institute should continue to grow.

Research Programs: Cartwright is a world leader in the study of deep sea tides. His team developed and perfected one of the first successful bottom-mounted deep sea tide gauges which they are systematically using in a study of tides in the North Atlantic Ocean. Dr. David Pugh is studying tides and anomalous sea level changes in the Indian Ocean. The dynamics modeling group headed by Dr. N.S. Heaps is concerned with developing numerical models of the British continental shelf seas, the North Sea, and adjacent ocean regions. He is particularly interested in improving methods for forecasting storm surges that threaten parts of London and other ports. Earth tides are measured by a geophysics group under Dr. T.F. Baker. Dr. J. Huthnance is carrying out research in coastal trapped waves in a stratified ocean. Dr. I.O. James has been concerned with frontal systems, the near surface thermal structure, heat budgets, and mixing in shallow seas. Mr. G.A. Alcock is working with Cartwright on "SEASAT" radar altimetry.



He is calculating the deformation of local sea areas due to tides and weather for all relevant altimetry data to calculate tides in areas where they have not been measured.

Technology Transfer: IOS Bidston along with other IOS laboratories operates a marine information and advising service (MIAS) which functions in a similar manner to the US university sea grant program. MIAS, which is largely housed at Bidston, appears to be a highly customer-oriented organization that is making a worthwhile contribution to the ocean-oriented UK. MIAS has one of the best and most thorough systems for helping the public by supplying marine information. Several processing and presentation programs have been developed to meet customers' standard requirements. These include extreme value predictions, percentage exceedance diagrams, persistence plots, progressive vector diagrams, as well as maps. Data can be selected by geographical area, parameter, date, season, depth, cruise, or project. Output may be provided as tabular print-outs, graphical plots, microfiche, or on magnetic tapes.

Comments: Excellent in all respects. The UK is really getting its money's worth out of the efforts of IOS Bidston. See ESN 33-10:425 (1979), 33-11:468 (1979), and, for a more historical account, ONRL R-4-79.

Institution: Dunstaffnage Marine Research Laboratory, Oban, Scotland.

Division: Physical Oceanography Group.

Key Personnel: Director, Prof. Ron Currie; Head of the Physical Oceanography Group, R. Bowers.

Trends: There is evidence that the laboratory has been rapidly expanding its staff in physical oceanography. Most of the staff are new, young, and enthusiastic. A new, specially designed research vessel of about 100 tons is being built for use in the inland waters of sea lochs and between the islands northwest of Scotland.

Research Programs: The Physical Oceanography Group is primarily interested in the currents and water masses of the western saltwater lochs (fjords) of Scotland and the ocean in a 600 mile arc north and west of Scotland. The sea lochs are important as tourist attractions and for aquaculture. They are also attractive sites for certain industries with potential for pollution. The broad continental shelf northwest of Scotland and the shallow Rockall bank (the size of Ireland) farther offshore are under intense study because of their potential oil resources.

Funding: The principal source of funds is the Natural Environment Research Council. A substantial proportion of the budget comes from various industries for base line studies and environmental impact studies.

Comments: This laboratory is known for its high quality descriptive physical oceanographic work. See ESN 33-11:469 (1979).

Institution: Heriot-Watt University, Edinburgh, Scotland.

Division: The Institution of Offshore Engineering, and 11 other departments that carry out research on problems associated with the UK's North Sea oil industry.

Key Personnel: Director, Dr. Cliff Johnston.

Trends: The Institute has grown rapidly along with the offshore oil industry. It is dedicated to solving engineering, scientific, economic, and environmental problems for the industry.

Research Programs: One of the most important programs is the development and improvement of *in situ* instruments to monitor the condition of oil-well heads, pipelines, and other equipment in the hostile environment of the bottom of the North Sea. Pre-site physical, biological, and chemical surveys are made for shore-based oil and gas terminals and for offshore oil and gas drilling platforms. Environmental impact studies are made prior to construction. They are determining the constituents of oily water effluents from ballast water and leakage from oil terminals and refineries including trace metal contents.

The University has an extremely sophisticated wave tank capable of producing any type of wave spectra for testing models of single point mooring systems for super tankers.

Funding: Approximately one third comes from the Science Research Council and the Natural Environment Research Council, and the remainder from contracts from industry.

Comments: This university is noted for its high-quality innovative research into many phases of ocean engineering related to the North sea oil industry. See ESN 34-1:38 (1980).

Institution: University College of North Wales, Bangor (Menai Bridge), Wales.

Division: Department of Physical Oceanography.

Key Personnel: Chairman, Prof. John Derbyshire.

Trends: The Marine Science Laboratory, consisting of the Departments of Physical Oceanography and Marine Biology and the Unit of Marine Invertebrate Biology of the Natural Environment Research Council (NERC), appears to be growing with funding available for a new auditorium, a library, and a new building for physical oceanography. The laboratory is unique in having its own 26.8 m research vessel independent of the NERC fleet. This is part of one of the largest university marine science complexes in Western Europe.

Research Programs in the Department of Physical Oceanography: The chairman's personal research is concerned with wave-related beach processes including rip currents, cusps and erosion. There is a major program in the structure and dynamics of shelf seas and frontal structures in shelf seas and estuaries and in modeling tidal streams around the United Kingdom. The Department is carrying out a detailed continuing study of the chemistry of Liverpool Bay in the Irish Sea between the north coast of Wales and the Isle of Man. A team of geotechnologists is studying the load-bearing properties of marine sediments primarily for the large structures used in the North Sea oil production industry. Geophysical techniques are being used to define *in situ* dynamic properties in sea floor sediments.

Comments: This laboratory is noted for its excellence in the study of the structure and dynamics of shelf seas and its program in geotechnology. See ESN 34-5:237 (1980).

Institution: The Aberdeen Laboratory of the Scottish Department of Agriculture and Fisheries.

Division: Programs in Physical and Chemical Oceanography.

Trends: These relatively small programs are in support of the researchers in fisheries at the laboratory and have remained the same size for a number of years.

Research Programs: Their primary interest is in the currents and water mass characteristics of the continental shelf surrounding Scotland, including the northern part of the North Sea and the area around the Shetland Islands. They provide regular measurements of the main physical and chemical characteristics of Scottish shelf waters so that a picture of the seasonal and annual fluctuations can be obtained and their influence on the distribution, composition, and abundance of commercial fish stocks can be obtained. They are also doing systematic current meter surveys to determine the pattern of residual (non tidal) currents that are important in moving pollutants and immature stages of commercial species of fish. A major effort is being expanded on trying to determine what long-term changes in the marine environment in the North Atlantic may be related to the varying abundance of salmon. The chemistry group has been mainly concerned with the distribution of nutrients in the area. Now they are working almost exclusively on the effects of trace metals on marine organisms and the concentration of all heavy metals and pesticides in commercial fish and shell fish in the North Sea.

Funding: Governmental appropriations.

Comments: Most of the oceanography is descriptive and statistical in nature because of its use in fisheries studies. See ESN 34-6:293 (1980).

## PORTUGAL

## I. Summary

Marine Science in Portugal is centered in the following institutions: The Hydrographic Institute of the Navy, the Navy's Vasco da Gama Aquarium, the University of Lisbon, and the National Civil Engineering Laboratory. The programs at the Vasco da Gama Aquarium and the University of Lisbon are quite small and do not appear to be growing. The other two are expanding. All are located in Lisbon. The bulk of the effort is tied into better utilization of marine resources (mostly fisheries products), increasing the power supply needed for industrial development without degrading the environment, and civil engineering related to beaches, ports, and harbors. The physical, chemical, and geological oceanography of Portuguese continental waters are undergoing a thorough study. Students can receive limited training in physical oceanography at the University of Lisbon. The Navy plans to train its officers in an inhouse program.

## II. Comments

The overall effort in marine science in Portugal has increased materially in both quantity and quality during the past few years and there are signs that it will continue to increase. Closer collaboration between marine scientists at the University of Lisbon and the Hydrographic Institute of the Navy would be desirable. The former would benefit from a modest increase in funding and more opportunity to use the Navy's research vessels and equipment. The Navy could make use of the university's expertise in physical oceanography in its educational program and in helping to plan experiments to solve particular problems at sea.

Institution: Portuguese Navy.

Division: Hydrographic Institute, Lisbon.

Key Personnel: Lieutenant Commander Antonio Souta, Lieutenant Victor Goncalo.

Trends: The overall program at the institute is undergoing a rapid development which began in 1974. Ten officers are at present in training in the United States at the US Naval Naval Postgraduate School and Navy Oceanographic Office, Bay St. Louis, MS. A formal postgraduate course in oceanography is scheduled to be initiated this year at the Hydrographic Institute. The trend in the oceanographic programs is toward practical and applied research and surveying (that which will be of benefit to the civilian community). The highest priority is given to the gathering of physical, chemical, geological and climatological data to be used in helping decision makers improve plans for diversified use of Portugal's bays, estuaries, saltwater lagoons, and coastal and continental shelf waters. The data are for use in planning sites for nuclear and coal-fired power plants on the coast.

The most recent major shift in emphasis at the Institute has been to increase the level of effort in pollution related research, including monitoring pollutants in the marine environment.

Research Programs: Investigators at the Hydrographic Institute are obtaining data to be used to estimate the rate of diffusion of cooling water discharged from proposed coastal electric power plants. They are also

determining in detail the current distribution in shelf waters surrounding the country, using conventional geostrophic techniques and *in situ* current meter arrays. In addition, they are recording sea and swell statistics with waveriders and shorebased radar at various locations on the coasts of Portugal to derive sea and swell climatological statistics. In another effort, they are determining the distribution of temperature, salinity, dissolved oxygen, and nutrients in shelf waters. Finally, they are mapping the distribution of bottom-surface and near-bottom sediments to depths of 2-4 m on the surrounding continental shelf.

Technology Transfer: There was no discussion of technology transfer. It was assumed that transfer of information to the public is done through other governmental agencies which fund various parts of research and survey programs.

Funding: Half of the funds are appropriated by the Navy. The other half come from other governmental agencies who request and pay for specific studies and surveys. The principal supporting agency is the National Commission Against Pollution at Sea.

Comments: The programs are descriptive in nature. See ESN 34-3:137 (1980).

Institution: Vasco da Gama Aquarium, Lisbon.

Trends: Concentration on aquaculture research at the expense of previously emphasized classical marine biological studies.

Research Programs: The aquarium is developing and improving a system for raising sole from eggs to commercial size. The aim is to make commercial sole farms feasible. It is also developing techniques for catching eel elvers and raising them on a commercial basis in captivity.

Source of Support: The Navy.

Comments: This laboratory has a very small research program. See ESN 34-4:137 (1980).

Institution: University of Portugal, Lisbon.

Division: Physical Oceanography Group, Geophysics Center, Department of Physics.

Key Personnel: Dr. I. Isabella Amber, her husband, Mr. Armando Fuiza, their assistants and students make up the group.

Trends: Since the inception of the program in the early 1970s, it appears to have remained small and has been devoted to continued study of the physical oceanography of the area.

Research Programs: Amber and Fuiza are dedicated to the study of the dynamics of coastal and ocean waters near Portugal. These include the study of warm, saline Mediterranean Sea waters that penetrate the Atlantic at depth after it flows over the sill at the Straits of Gibraltar and airborne radiometric studies of upwelling along the coast of Portugal.

Technology Transfer: This is done through publication in scientific journals.

Funding: This subject was not discussed. However, there was evidence that their projects were underfunded considering their training, experience, and enthusiasm, and the need for some basic research in physical oceanography. Unfortunately, Portugal does not seem to have a counterpart of the US National Science Foundation to support basic research in the universities.

Comments: This small program was underfunded but still seemed to turn out good results. See ESN 34-4:139 (1980).

Institution: National Civil Engineering Laboratory, Lisbon.

Key Personnel: Director, Julio F. Borges; chief of the Hydraulics Division, E.N. Manzanares-Abecasis.

Trends: The entire laboratory is growing steadily. The trend in the Marine Section of the Hydraulics Division is to make increasing use of mathematical models to arrive at solutions to problems in coastal and harbor engineering. The next step is to construct physical models to test and improve mathematical models.

Research Programs: The laboratory has built a new wave generator capable of generating any desired multi-directional wave spectra. Tidal and current data are collected in order to design models to study how navigation can be improved in restricted waters. Other models are used to predict thermal diffusion rates and patterns in lagoons and estuaries, for wave refraction, to study littoral drift, and to study resonate seiches in harbors.

Funding: This comes primarily from the Ministry of Public Works, with lesser amounts from other governmental agencies. A small amount also comes from harbor engineering studies for former Portuguese colonies.

Comments: Very good. See ESN 34-3:139 (1980).

## THE NETHERLANDS

## I. Summary

Most of the oceanographic research in the Netherlands is carried out in the following three institutes: The Netherlands Institute for the Scientific Studies of the Sea (NIOZ), the Oceanographic Division of the Royal Netherlands Meteorological Institute (KNMI), and a small program at the Free University of Amsterdam. NIOZ, on the island of Texel, has programs in physical and chemical oceanography of shallow seas and coastal waters, marine optics, and turbulence. KNMI, in De Bilt (Utrecht), is dedicated to practical applied research in physical oceanography and meteorology, the results of which will help to improve the forecasting of storm surges, residual (pollution distributing) currents, sea and swell, and ship routing. The researchers at KNMI concentrate on the North Sea but do some work in the North Atlantic as well.

## II. Comments

The Netherlands, because a large share of its land area is below sea level, is very dependent upon the vagaries of the North Sea, the shipping industry, and resources from the sea. The government appears to realize that the future prosperity of the country depends on improving the fund of knowledge concerning the seas and oceans. For this reason there has been a steady growth in recent years in funding for oceanographic research, especially at NIOZ. The programs that I studied in detail were all excellent ones with cadres of well trained, enthusiastic, relatively young researchers. Equipment and research facilities were more than adequate. A large new naval oceanographic research vessel is available for the use of both laboratories. Although the Netherlands' programs are relatively small in size when compared with those of larger laboratories in larger countries, the work being done is on a par with work in the better laboratories in the United States and western Europe. Courses in marine science are being taught at the Universities of Utrecht and Groningen.

Institution: Nederlands Institution voor Onderzoek der Zee, NIOZ, (Netherlands Institute for the Scientific Study of the Sea) Texel.

Division: Physical Oceanography.

Key Personnel: Prof. H. Postma and Dr. J.J. Zilstra, co-Directors.

Trends: The physical oceanography program had long been minimal, with only one specialist working in current and water mass studies. In the past several years four additional physical oceanographers have been added to the staff to study marine optics and turbulence and mixing. There are plans to double the number of physical oceanographers in the next few years.

There appears to be a trend toward more work in the North Sea and the Atlantic Ocean now that the large new navy research ship, *Tydeman*, is available on a part-time basis (15%) to researchers at NIOZ.

By charter, NIOZ is the center for basic marine research. When I visited it in 1966, the research program was largely devoted to marine biology and chemistry. The institute has grown very rapidly and now has programs in chemical, physical, geological, and biological oceanography, fisheries, and pollution.

Research Programs: Dr. J.F.T. Zimmerman has spent much of his time studying mixing, flushing, and residual currents of the Wadden Sea which is extremely important to the Netherlands as a nursery for immature stages of some commercially important species of fish. He also works on the heat

balance of tidal flats which is a major factor in their productivity. Some of his research methods are applicable to the study of the dynamics of other shallow seas and estuaries.

Dr. D. Spitzer and Mr. M.R. Wernard have recently developed their own scalar irradiance meter to measure the spectral distribution of solar energy as a function of depth. It is relatively simple, inexpensive, and reliable. This program was recently developed to support deep-ocean primary-productivity studies by chemists and biologists at the institute. Mr. C. Veth and Mr. M.W. Manuels have designed and constructed an *in situ* laser-Doppler velocimeter to study turbulence in the sea. The method has some very useful properties in its fast response to velocity changes, a very small measuring volume and, in principle, its lack of influence on the measuring system on the flow. It gives two components of the velocity with a threshold velocity of 0.2 m/sec. Laboratory experiments show that turbulence spectra with frequencies up to 2 kHz can be measured. If it works in the laboratory, it will be a unique and very useful tool.

Technology Transfer: The institute publishes its own *Netherlands Journal of Sea Research*. Papers from the institute are also published in scientific journals.

Funding: Direct grants from the Netherlands government.

Comments: Excellent. See ESN 33-7:296 (1979).

Institution: The Free University of Amsterdam.

Division: Oceanography Group of the Sub-faculty of Geology and Geophysics.

Key Personnel: Dr. Hans F. Vugts, Prof. H. Tennekes.

Trends: Dr. Groen, the former division chairman, retired in 1979, and oceanography training and research ceased to exist at the Free University of Amsterdam. The group is now specializing in boundary layer meteorology under the part-time direction of Tennekes. Although oceanographic research is not undertaken, the present research projects are related to the sea. These include: atmospheric boundary layer changes when wind blows from the sea over the land, heat budgets of tidal flats, and the microclimate of coastal sand dunes.

See ESN 33-5:176 (1979).

Institution: Royal Netherlands Meteorological Institute (KNMI).

Division: Department of Oceanography, DeBilt.

Key Personnel: Prof. P. Dorrestein is the head of the Research Section and professor of meteorology at the Free University of Amsterdam; Prof. H. Tennekes (formerly on the staff of Penn State University).

Trends: There has been an increase in open ocean physical oceanographic studies since the Dutch navy research ship *Tydeman* was put in operation last year. This research includes air-sea interaction, the dynamics of the formation and dissolution of the seasonal thermocline, and the study of oceanic fronts. A good deal of effort is presently being expended to improve the quality of wind measurements at sea and to gather ground (sea surface) data for calibrating and evaluating satellite sensors. An oceanographic data center has recently been housed within the oceanographic quarters of KNMI. It is unique in that its computer archives do not contain any data other than the location and description of data stored in various research centers



in the Netherlands. It serves only as a clearing house for exchange of oceanographic data. See *ESN* 33-9:345 (1979).

Research Programs: The policy of the department is to select research programs involving both meteorology and oceanography. The department is dedicated to practical applied research, the results of which can be used to improve the services of KNMI in weather forecasting as well as ship routing and forecasting storm surges, residual currents, and sea and swell.

Dr. E. Bouws is studying the wind and wave climatology of the shallow Netherlands sector of the North Sea in order to determine the maximum wave or swell heights that will strike engineering structures such as gas well platforms.

Dr. W.A. Oost is designing an improved anemometer for use on platforms at sea. Mr. C.G. Korevaar is constructing a marine atlas of weather and sea surface characteristics and is working on improvements to ongoing ship routing procedures used by KNMI. Dr. H. Timmerman is constantly working on improving storm surge forecasting techniques, one of the most important forecasts made by KNMI on a routine basis.

Dr. P. Kruseman and G.V. Prangsma are interested in the near surface temperature distribution in the ocean, fronts, seasonal thermocline, advection, and their effects on weather. They believe that weather forecasting will be improved by including the effects of the near surface temperature distribution.

Mr. H.W. Riepma is primarily interested in the mechanisms causing residual currents in the North sea and the forecasting of them. These currents distribute pollutants from land. Wind, tide-bottom interactions, and external (to the North Sea) parameters all add contributions to residual currents.

Funding: Direct appropriations from the Netherlands government.

Comments: Most of the research is strictly applied. Researchers must work on subjects that will improve forecasting of storm surges, waves, etc., and are not allowed freedom to choose their own subject matter. See *ESN* 33-9:350 (1979).

## SPAIN

## I. Summary

Marine science in Spain is centered in the following institutions: The Spanish Institute of Oceanography with headquarters in Madrid and branch laboratories in Málaga, Mar Menor, Palma Mallorca, Santander, La Coruña, Vigo, and Santa Cruz de Tenerife; the Oceanographic Division of the Hydrographic Institute of the Spanish Navy in Cádiz; the Spanish Naval Observatory near Cádiz; the Institute for Fisheries Research in Barcelona; and smaller fisheries research laboratories at Vigo, Cádiz, and Torre de la Sol. The bulk of the research is being carried out in Spanish coastal waters and in bays and estuaries. The research, except for that at naval institutions, is primarily concerned with inventorying marine resources, developing aquaculture, pollution studies, and studies of the dynamics of continental shelf waters. The fisheries laboratory in Barcelona is in reality an oceanography laboratory with programs in most fields of marine science. The two naval laboratories are solely concerned with physical and geophysical research of interest to the Navy. Spain has no training programs in oceanography.

## II. Comments

The oceanography program at the Hydrographic Institute is very narrowly based on studies of temperature and salinity. The people I talked to seemed to be enthusiastic and competent. The main thrust of the institute is to chart accurately the depths in shallow waters around Spain. They are well equipped for this and, judging from the products I was shown, are skilled at charting.

I was deeply impressed by every aspect of the Spanish Naval Observatory, in particular its up-to-date and comprehensive graduate course in geophysics offered primarily to Spanish Naval officers. Most of the staff who discussed their work with me spoke excellent English and had earned their PhD degrees in the United States.

Institution: The Spanish Institute of Oceanography.

Division: The headquarters and largest laboratory in Madrid and smaller branch laboratories in Málaga, Mar Menor, Palma Mallorca, Santander, La Coruña, Vigo, and Santa Cruz de Tenerife in the Canary Islands.

Key Personnel: Director, Dr. José M. Turnay, head of the Physical Oceanography Department; Mr. Julian Gomez; and senior members of the Physical Oceanography Department, Gregario Parrilla and Federico Fernandes.

Trends: The current principal field program of the Department of Physical Oceanography is a comprehensive study of currents and water masses of the Alborán Sea and the Straits of Gibraltar between southern Spain and North Africa. Pollution research in Spain's many bays, estuaries, and fjords has a high priority. A new Department of Aquaculture has recently been added to the Institute. Its purpose is to develop aquaculture programs in Spain's numerous bays and estuaries to replace some of the seafood that is no longer available to Spain with the advent of the 200 mile economic and fisheries zone limitation. There is a trend toward developing multidisciplinary teams within the institute to attack environmental problems.

Research Problems: Geology, with projects in mineralogy, prospecting, and sedimentology; Marine Biology, with projects in planktonology, productivity, and ecology; Contamination, with programs to survey Spanish coastal waters, bays and estuaries for pollutants and to study methods for protec-

ting marine structures from pollutants and sea water; Fisheries Technology and Biology, with programs to improve technology of catching fish, fisheries biology, and research on how to obtain maximum sustained production in the various fisheries; Aquaculture; and Physical Oceanography.

The Alborán Sea study is concerned with how Atlantic water enters the Strait of Gibraltar and flows into the Mediterranean Sea; how the Atlantic water is then distributed; how and where it mixes with Mediterranean water; and the currents and eddies associated with it. Acousticians want temperature-salinity data to compute the depth of sound channels and the location of shadow zones. Marine biologists need to know hydrographic conditions in their study of the adaptation and development of marine plants and animals. The physical oceanographers are also studying wind-induced and orographic upwelling in the northeast part of the sea which enrich the area by bringing nutrients to the surface. The institute also carries out multidisciplinary pollution studies for private companies.

Technology Transfer: The institute publishes its own *Boletín del Instituto Español de Oceanografía*. I was shown several large 2-inch-thick reports which go into great detail describing oceanographic conditions in bays and estuaries that are polluted or threatened by pollution from various new or projected industries. See ESN 34-4:191 (1980).

Funding: The institute is now a part of the Sub-section for Fisheries and Merchant Marine of the Ministry of Transport and Communication which funds most of its research. The Alborán Sea study is partially supported by a subcontract with Woods Hole Oceanographic Institution which has a NOAA contract for this research. Private companies support some of the marine pollution research.

Comments: In visits to the main laboratory of the Spanish Institute of Oceanography in Madrid (1973 and 1979) and branch laboratories in Málaga (1979) and Vigo (1973) I observed that the institute had little in the way of modern oceanographic equipment. The Málaga and Vigo laboratories bordered on the austere, with small staffs and little equipment. Most of the research is descriptive. Neither has its own research vessel. All branches depend on a single oceanographic vessel based in Vigo. See ESN 34-4:191 (1980).

Institution: Hydrographic Institute of the Spanish Navy.

Division: Oceanography Division, Cadiz.

Key Personnel: Director, Rear Admiral V. Gandaris; head of the Oceanographic Division, Captain S.S. Lopez.

Trends: The oceanography division is only 12 years old. Two signs of its growing strength are the facts that a new oceanographic building is scheduled to be built in the near future and that two naval officers who are candidates for master's degrees in oceanography at the US Naval Postgraduate School will be the first two officers to be permanently assigned to the division.

Research Programs: The primary emphasis in the Oceanography Division is on determining the distribution of temperature and salinity for underwater sound-path predictions.

Funding: Spanish Navy.

Comments: Good quality descriptive oceanography. See ESN 34-4:191 (1980).

Institution: The Spanish Naval Observatory, near Cadiz.

Key Personnel: Commander Manuel Catalan, assistant director.

Trends: The latest additions to the observatory are a precise laser-ranging device for use with satellites and homemade proton fluxgate and optical pumping magnetometers which are shared with the nearby Institute of the Spanish Navy.

Research Programs: Marine research at the Observatory includes seismic and magnetic surveys and the study of plate tectonics.

Technology Transfer: Through its own publications and through publications in scientific journals.

Funding: Primarily from the Spanish Navy. It should be noted that the observatory appeared to have the very latest equipment and to be in a favorable position as far as funding was concerned.

Comments: Excellent in all respects. See ESN 34-6:281 (1980).

Institution: The Institute for Fisheries Research, Barcelona.

Key Personnel: Director, Dr. B. Andrew Morena.

Trends: The three branch laboratories, at Vigo, Cadiz, and Torre da la Sol, became independent of the Barcelona Laboratory last year, and all four laboratories are now under the direction of the National Fisheries Center in Madrid. As is true with many European marine science laboratories, the Barcelona laboratory is emphasizing marine pollution research more and more.

Research Programs: The Department of Oceanography, headed by Dr. A. Ballister Nolla, is a catch-all department with programs in microbiology, the chemistry of photosynthetic pigments, current water mass characteristics of Spanish coastal waters and the rich upwelling region off the northwest coast of Mauritania, and a study of the chemistry and radioactivity of bottom sediments. A systematic current survey of shelf waters off eastern Spain is being carried out in order to find out where effluents from coastal outfalls will go. The large Department of Marine Biology, headed by Dr. Francisco Galines, is divided up into the following groups: Benthos, Zooplankton, and Phytoplankton.

The Benthos Group is describing the littoral benthos communities along the Catalanian coast, studying the effectiveness of 35 new antifouling paints, and getting ready to establish an artificial reef near Barcelona.

The Phytoplankton Group does work on the biomass, productivity, taxonomy, and analysis of the constituent species of individual communities. The group usually works in Spanish waters but has also studied upwelling regions off northwest Africa. The researchers are monitoring phytoplankton along the coast of Spain.

The Zooplankton Group is continuing the study of the biomass, structure of populations, and ecological aspects of several different groups of zooplankton in Spain's littoral waters with particular emphasis on zooplankton communities in polluted areas. The Department of Marine Resources is headed by Dr. C. Bas Peireol. It is primarily concerned with commercial species of fish and shellfish—their distribution, abundance, food supply, growth rate, and the effort required to catch them. In addition to working in Spanish waters the group is cooperating with the Sea Fisheries Institute of South Africa in making a major study of the fisheries in the southwestern Atlantic Ocean with emphasis on the rich upwelling region associated with the Benguela Current northwest of Capetown.

Technology Transfer: The institute publishes scientific papers in

its journal *Investigación Pesquera* and practical information in technical reports similar to sea grant reports in the US.

Funding: Most of the funds for operating the Institute come from the Ministry of Education through the Consejo Superior de Investigaciones Científicas (Superior Council for Scientific Investigation) which is roughly equivalent to the US National Science Foundation.

Comments: It was difficult to assess the quality of research being carried out because I was only able to speak to the director. See ESN 34-6:291 (1980).

## FRANCE

## I. Summary

I have visited the three largest university and university-type oceanography laboratories in France. This report is primarily concerned with these laboratories: The Division of Physical Oceanography of the Museum of Natural History in Paris, the Laboratory of Physical and Chemical Oceanography of the Pierre and Marie Curie Campus of the University of Paris, and the Arago Laboratory of the same university, which is located at Banyuls-sur-Mer near the Spanish border not far from Marseilles. The Museum of Natural History Laboratory is across the street from the Pierre and Marie Curie campus and functions almost as if it were a part of the University of Paris. A large number of university students do thesis research at the Museum and the Museum staff teaches regularly at the university. The research programs are almost entirely devoted to expert fundamental research. Researchers make a great deal of use of numerical models for studying various interactions between the atmosphere and the oceans and Mediterranean Sea on all scales. They emphasize research programs to study the responses of the oceans to atmospheric forcing and the development and verification of fluid dynamic models of the ocean. The university laboratory in Paris concentrates primarily on all facets of light transmission, scattering, and absorption in the sea as well as the chemistry of dissolved and particulate matter in the sea including natural and spilled hydrocarbons. This laboratory also conducts the most comprehensive graduate program in France in the marine sciences as well as a graduate program in atmospheric sciences. The Arago laboratory is primarily devoted to classical marine biology of all kinds. It also has a two-man team doing physical oceanography, primarily optical oceanography and modeling the dynamics (including upwelling) of the currents and water masses in the northwestern Mediterranean Sea.

## II. Comments

Based on visits to the three major university and university type oceanographic laboratories in France, I would say that their research programs and research workers are first rate and comparable to the best anywhere. This is particularly true of the Laboratory of Physical Oceanography of the Museum of Natural History. All laboratories appeared to be well financed and to have good equipment. In addition to the above three laboratories there are a number of other smaller university laboratories in France that are doing good work. The Universities of Bordeaux and Perpignan have outstanding programs in marine geology. The University of Marseilles has a first-class marine science laboratory, and an elaborate combination wind-tunnel water-tank facility for air-sea interaction studies is located at the Institute for Mechanical Statistics of Turbulence in Marseilles. All of the above four laboratories and several others are scheduled to be visited during July 1980.

In addition to university-type laboratories there is a tremendous amount of ocean engineering going on in France. The largest center is the National Center for the Exploitation of the Oceans (CNEXO) in-house laboratory in Brest which will also be visited in July. Numerous industrial firms are also engaged in ocean engineering. Overall I would say that France is one of the leading countries in all aspects of Marine Science.

Institution: The National Museum of Natural History.

Division: The Physical Oceanography Laboratory, Paris.

Key Personnel: Director, Prof. H. Lacombe

Trends: Increased use of numerical models for studying various interactions between the oceans and the Mediterranean Sea and the atmosphere on all scales.

Research Programs: The two basic subjects that are emphasized in the research programs of the Physical Oceanography Laboratory are the study of the response of the ocean to atmospheric forcing and the development and verification of fluid dynamic models of the oceans.

The Turbulence Division under the direction of Maxence Revault d'Allones is determining experimentally the fractions of wind energy that are transferred to the oceans to generate waves, create currents, and mix or stir the near-surface water column and change the vertical distribution of potential energy and temperature in the ocean.

The Formation of Water Types Division, under the direction of Jean-Claude Gascard, is studying the processes through which approximately 36,000 km<sup>3</sup> of deep water are formed in the northwestern corner of the Mediterranean Sea each year. This is the original source region of the distinct Mediterranean type of deep water that eventually becomes widespread at depth in the Atlantic Ocean.

The Climatic Atlas Division, under the direction of Dr. Joseph Gonella, is preparing an atlas of the temperature and salinity of the Mediterranean Sea which is based on Nansen Bottle casts. Special emphasis is being given to sea surface temperature anomalies which Gonella feels are better indicators of climatic change than are air temperature variations.

The Mathematical Modeling Division, headed by Michel Crepon, is using satellite infrared imagery to pinpoint upwelling areas in the Gulf of Lions (near Marseilles) and to model the process. Crepon is also studying thermal forcing of currents in the North Atlantic ocean. His model indicates that thermal forcing is of the same order of magnitude as wind forcing. In addition, Crepon is working with meteorologists on a model of the atmosphere, using a seasonal time scale and taking into account feedback from the ocean. He is endeavoring to study variability over a ten-year period. Other models include the prediction of oscillating currents in the oceans from winds only of near-shore Kelvin waves.

Technology Transfer: This is done primarily by means of publications in scientific journals and reports to sponsoring agencies.

Although the Physical Oceanography Laboratory is a part of the Museum of Natural History, it functions almost as a department of the adjacent Pierre and Marie Curie campus of the University of Paris. Staff members of the laboratory teach at the university and quite a few graduate students do their research at the laboratory under the direction of staff members.

Funding: Only a small percentage of the laboratory's financial support comes from the parent museum. About one fourth comes from CNRS (The National Center for Scientific Research, a counterpart of the US National Science Foundation).

Over half of the laboratory's total funding, as well as the ships it uses, comes from CNEXO. A fundamental, unresolved problem has arisen concerning CNEXO funding. CNEXO, which wishes to support applied research, has chosen to emphasize support of operations, overhead, and equipment purchases rather than researchers' salaries. This is because of the fact

that if CNEXO supported salaries, it would be required under French law to give individuals tenure after a few years. CNEXO officials believe that under such circumstances, they would lose control over salaried individuals, who could drift away from applied research into basic research. This impass causes some difficulty in the management of the resources of the laboratory.

Comments: Excellent. See ESN 33-5:178 (1979).

Institution: The Pierre and Marie Curie Campus of the University of Paris.

Division: The Laboratory of Physical and Chemical Oceanography, Paris.

Key Personnel: Director, Prof. Alexandre Ivanoff; Dr. A. Morel, Director of the field station of the laboratory at Villefranche-sur-Mer (Nice).

Trends: The laboratory has grown rapidly since the last time I visited it. On three previous visits I found that the principal activity of the laboratory was research in marine optics. Recently it has added a research program in marine optics, and now it provides a broad spectrum of courses in physical and chemical oceanography and atmospheric sciences.

Research Programs: The Division of Optical Oceanography is headed by Dr. A. Morel. It is concerned with penetration of solar radiation into the sea and the effects of dissolved and suspended particulate material on the spectral distribution of solar radiation at various depths and places in the oceans. A CNEXO contract supports the development and testing of systems for remote sensing of the chlorophyll content of surface waters in the ocean. Morel's research is outstanding. A second division, headed by Dr. C. Copin is concerned with the chemistry, size distribution, and optical properties of suspended particulate materials in the oceans. The third division, headed by Dr. A. Asliot, is working on the organic chemistry of air-sea interface, the sediments and marine organisms. The group is determining the flux of marine fatty acids and aromatic hydrocarbons across the sea surface into the air—one source of natural pollution. A mass spectrometer is used to determine precisely the kinds of natural fatty acids and hydrocarbons in the ocean so that it can be established which hydrocarbons come from living marine organisms and which are from oil spills of fossil fuels (particularly the *Amoco Cadiz* spill on the Brittany coast). The fourth and last division, headed by Prof. J. Chanu is determining precisely the relationship between conductivity and density of sea water.

Technology Transfer: Papers in scientific journals and reports to sponsoring agencies.

Funding: The teaching program is supported by the University of Paris. The research programs are supported by CNEXO, CNRS, the Centre d'Etudes de Geochimie Marine of the Compagnie Francaise des Pétroles (Center for the Study of Marine Geochemistry of the French Petroleum Company), and the Association for Research and Development of Methods and Processes in Industry.

Comments: The marine optics, particularly that done by Morel, is on a par with the best programs in the US. See ESN 38-8:333 (1979).

Institution: Pierre and Marie Curie Campus of the University of Paris.

Division: Department of Zoology, Arago Laboratory, located at Banyuls-sur-Mer.

Key Personnel: Director, Prof. Jacques Soyer, Prof. B. Saint-Guily, Engineer M. Panouse.



Trends: The laboratory appeared to be stable with no obvious indication of recent growth. I was told that several years ago the laboratory had hopes and plans for expanding programs in physical and chemical oceanography. This has not materialized.

Research Programs: Saint-Guily, who is also affiliated with the Museum of Natural History, Laboratory of Physical Oceanography in Paris, is studying the process of upwelling and formation of deep water in the Gulf of Lions through the use of models, and on-the-spot temperature, also salinity, current, and meteorological data. He is studying planetary waves on the continental shelf off eastern Spain. Panouse is an optical oceanographer who was brought to the laboratory to be in charge of instrumentation and to furnish data on the spectral distribution of sunlight in the ocean for the 12-person plankton production team that is led by Dr. C. Razouls. The general objective of this team is to study the structure and operation of planktonic ecosystems in regions of upwelling, the productive areas in the Mediterranean Sea. Other studies underway include: pelagic production in a number of places in the oceans, bioenergetics of phytoplankton photosynthesis, fixation of CO<sub>2</sub> in phytoplankton, the global budget of the exchange of carbon between the milieu and phytoplankton, and morphological and physiological adaptations of mesoplankton to the environment.

The benthic ecosystem team is by far the largest team in the laboratory with 17 members including the Director, Soyer. The head of the team is Dr. Aline Fiala. Its primary interest is in energetics of the coastal benthic ecosystem. Research *in situ* and in the laboratory are carried out simultaneously. Field work consists of obtaining data on the seasonal cycle of nutrients available to the benthic community, determining the populations of bacteria, and studying the biological cycles and population dynamics of important species.

The cellular biology team of seven persons is headed by Dr. Marie-Odile Soyer. The principal subject of research is the study of composition of dinoflagellates. They are studying the chromosome structure and cell chemistry of these animals and are making biochemical analyses of their chromosomal nucleofilaments (DNA proteins).

Comments: Saint-Guily research is excellent. See ESN 34-4:187 (1980).

## GREECE

## I. Summary

Marine research in Greece is centered in the Departments of Inorganic Chemistry, Botany, Zoology, and Geology at the University of Athens, the government Nuclear Research Center in Athens, the government Institute of Oceanography and Fisheries near Athens, and the Division of Oceanography of the Hydrographic Office of the Greek Navy in Athens. Research is almost entirely limited to the many bays and estuaries in Greece and the surrounding waters of the Aegean and Ionian Seas. University programs and the program at the Nuclear Center are primarily devoted to marine pollution in all its facets. The Institute of Oceanography and Fisheries also concentrates on marine pollution problems along with all types of fisheries research. The oceanography program in the Navy has been devoted to practical oceanographic survey work of interest to the Navy: waves, tides, temperature, salinity, and sediment distribution. However, the program is scheduled to double in size within the next few years to include a major survey related to locating outfalls from cities and developing industrial sites.

## II. Comments

Previous ONR London reports on marine science at the University of Athens gave a rather gloomy picture of the quality, quantity, and future of marine research there. I am happy to report that the situation has markedly changed. See ESN 34-7:349 (1980). There is an air of movement and optimism. Certainly the research programs that were presented to me were excellent. I had no way of knowing how adequate the funding was but I gathered that it was not high. However, most of the research is pollution oriented and as such receives some support from the Greek government.

A very comprehensive interdepartmental teaching program has recently been established that will help insure an adequate pool of trained marine research workers. As in the University of Athens, there is an air of progress and optimism in the Greek government laboratories. The quality and level of effort in marine science in Greece is creditable for such a small, austere country. Most of the efforts in the Institute of Oceanography and Fisheries and the Division of Oceanography of the Navy go into routine surveys and would not necessarily be classed as research. High-level research on the effects of pollutants on marine organisms is being undertaken in the Nuclear Center. My recommendations would be to establish a chair in physical or chemical oceanography at the university, to equalize the funding so that the university received a larger share, and to free marine science researchers at the university from their present massive undergraduate teaching loads so that they could engage in more research and pay more attention to graduate studies.

Institution: Institution of Oceanography and Fisheries Research, El-linika (Athens).

Key Personnel: Director General, Prof. V. Vambacas.

Trends: There was evidence of rapid growth during the past few years. Pending legislation will enlarge the charter of the laboratory to include all types of marine research except ocean engineering. The air of optimism and the pending new charter indicated that Vambacas believed that the laboratory will continue to grow.

Research Programs: Systematic surveys are being made of bays and

gulfs in Greece. These include temperature, salinity, tides, and in some cases, the distribution of nutrients. Closely spaced bottom sediment samples are studied for size distribution, organic content, clay minerals, and heavy metals. Seismic sub-bottom profiles are routinely carried out. The amount and kind of suspended material is also determined. This summer a very comprehensive study of Saronikas Gulf near Athens will be undertaken for four months. Marine chemists are studying distribution of nutrients, the products of decomposition of organic matter, the distribution of trace elements in organisms and sediments, the distribution of chlorinated hydrocarbons from pesticides, and evidence of pollutants originating from oil spills.

Funding: The major source of funding is the Public Investment Service of the Ministry of Coordination. The Ministry of Public Works pays for sewer outfall studies and the Ministry of Agriculture pays for all fisheries research. Small amounts come from private companies in need of oceanographic data for engineering purposes.

Comments: The studies on the effects of pollutants on marine organisms were excellent. Much of the physical oceanography is simple descriptive oceanography. The chemical program, though small, was excellent. See ESN 34-7:346 (1980).

Institution: The Division of Oceanography of the Hydrographic Office of the Greek Navy.

Key Personnel: The Chief of the division, Mr. B. Roufozales.

Trends: Plans are underway to double the size of the oceanographic division during the next two years. In addition to the standard oceanographic studies now underway, the division will begin a major study of oceanographic conditions around present and potential sites of sewers and outfalls from major cities.

Research Programs: All Navy research is restricted to Greek waters and the Ionian and Aegean Seas, bays, gulfs, and straits with particular emphasis on the Aegean Sea. Research is mainly in physical oceanography including studies of temperature, salinity, dissolved oxygen, pH, and sound velocity. In addition, bottom samples are taken and side-scan sonar and sub-bottom profiling are used to study the sea floor. The Greek Navy operates 34 tide stations, 70 meteorological stations in ports and harbors, and 54 stations where water temperatures are recorded every four hours.

Technology Transfer: The division issues an impressive array of books and charts summarizing the above data showing means, extremes, annual variations, and other statistical parameters.

Funding: Presently most of the funding comes from the Greek Navy. The new pollution related research will be funded by the Ministry of Public Works.

Comments: It was difficult to assess this program because I was not able to obtain sufficient detailed information. See ESN 34-7:346 (1980).

Institution: The University of Athens.

Key Personnel: Drs. M. Scoullou, A. Zamini, Prof. V. Kiortsis and Prof. K. Anagnostidis.

Trends: All programs have grown since the University was last visited

in 1973. A new interdepartmental MS program in general oceanography has about 25 enrollees. Scoullou has just started a research program in marine chemistry.

Research Programs: Scoullou is doing research on heavy metals in the marine environment and studying the chemistry of marine areas that may soon be polluted by effluents from new heavy industry. Zamini's group is studying bottom sediments in Greek bays and estuaries, deltaic deposits and Pleistocene marine deposits. Kiortsis' group is working on the physiological effects of pollutants on marine organisms. Anagnostidis' group is studying the assemblages of diatoms that develop in various concentrations and mixes of pollutants in marine areas.

Funding: Small grants from various government agencies. See ESN 34-7:349 (1980).

Institution: Democritus Nuclear Research Center.

Division: Radio Chemistry Laboratory.

Key Personnel: Director A. Grimanis.

Trends: The laboratory was not large enough when the last ESN was written on marine science in Greece in 1973. It now has three senior researchers and a number of students from the University of Athens working on PhD theses research.

Research Programs: The laboratory is primarily interested in the distribution of heavy metals in sea water, sediments, and marine organisms.

Funding: Greek Atomic Energy Commission.

See ESN 34-7:348 (1980).

